

WHAT IS CLAIMED IS:

- 1 1. A method of removing material from a vascular site, comprising the
2 steps of:
3 providing a device having an expandable cage and a material removing
4 element, the expandable cage being movable from a collapsed position to an expanded
5 position, the expandable cage also has a plurality of openings therein when in the
6 expanded shape, the openings being formed by rigidly connected elements;
7 advancing the device to a vascular site where material is to be removed;
8 expanding the expandable cage within the narrowed region of the blood vessel
9 so that material extends through at least some of the openings; and
10 removing the material extending through the openings in the cage.
- 1 2. The method of claim 1, wherein:
2 the providing step is carried out with the expandable cage being naturally
3 biased toward the expanded position; and
4 the advancing step is carried out with the expandable cage being held in the
5 collapsed position.
- 1 3. The method of claim 2, wherein:
2 the advancing step is carried out with the expandable cage being contained
3 within a sheath which holds the expandable element in the collapsed position.
- 1 4. The method of claim 1, wherein:
2 the providing step is carried out with the rigidly connected elements being
3 integrally formed elements.
- 1 5. The method of claim 4, wherein:
2 the providing step is carried out with the integrally formed elements forming a
3 smooth inner surface in the expanded position; and
4 the removing step is carried out with a material removing element passing
5 along the smooth inner surface.

1 6. The method of claim 1, wherein:
2 the providing step is carried out with the expandable cage having at least three
3 openings.

1 7. The method of claim 1, wherein:
2 the providing step is carried out with the expandable cage having at least four
3 openings.

1 8. The method of claim 1, wherein:
2 the providing step is carried out with the openings having a size of at least 0.25
3 mm² when expanded.

1 9. The method of claim 8, wherein:
2 the providing step is carried out with the openings each having a size of at
3 least 0.50 mm² when expanded.

1 10. The method of claim 1, wherein:
2 the providing step is carried out with at least one of the openings having a
3 length measured in a longitudinal direction of at least 0.020 inch.

1 11. The method of claim 10, wherein:
2 the providing step is carried out with at least one of the openings having a
3 length measured in a longitudinal direction of at least 0.040 inch.

1 12. The method of claim 1, wherein:
2 the expanding step is carried out with the expandable cage being expanded
3 within a stent.

1 13. The method of claim 1, wherein:
2 the removing step is carried out with a material removing element having a
3 flexible bag attached thereto for trapping the material which has been removed.

1 14. The method of claim 1, further comprising the step of:
2 vibrating the cage during at least one of the vibrating and removing steps.

1 15. The method of claim 1, further comprising the step of:
2 releasing the cage; and
3 removing the device while leaving the cage within the patient.

1 16. A device for removing material from a vascular site, comprising:
2 a cage which is movable from a collapsed position to an expanded position,
3 the cage having a plurality of openings in the expanded position, the openings being
4 formed by rigidly connected elements, the cage having an inner surface; and
5 a material removing element positioned within the cage to remove the material
6 extending into the openings.

1 17. The device of claim 16, wherein:
2 the cage forms at least three openings in the expanded position.

1 18. The device of claim 16, wherein:
2 the cage forms at least four openings in the expanded position.

1 19. The device of claim 16, wherein:
2 the cage forms 2-10 openings in the expanded position.

1 20. The device of claim 16, wherein:
2 the cage is naturally biased toward the expanded position.

1 21. The device of claim 16, further comprising:
2 a sheath;
3 the cage being contained within the sheath when in the collapsed position, the
4 sheath being retractable relative to the cage for exposing the cage and permitting the
5 cage to expand.

1 22. The device of claim 16, wherein:
2 the rigidly connected elements are formed with integrally formed elements
3 made of the same material.

1 23. The device of claim 22, wherein:
2 the integrally formed elements of the cage are made of a superelastic material.

1 24. The device of claim 16, wherein:
2 the openings have a size of at least 0.5 mm² when expanded.

1 25. The device of claim 16, wherein:
2 the openings have a longitudinal length of at least 1 mm when expanded.

1 26. The device of claim 16, wherein:
2 the cage is releasable from the rest of the device.

1 27. The device of claim 16, further comprising:
2 means for vibrating the cage.

1 28. A device for removing material from a vascular site, comprising:
2 a sheath;
3 an expandable cage movable from a collapsed position to an expanded
4 position, the cage forming a plurality of openings in the expanded position, the
5 expandable cage being contained within the sheath in the collapsed position so that
6 the sheath holds the cage in the collapsed position;
7 the sheath being retractable relative to the cage to expose the cage and permit
8 the cage to expand; and
9 a material removing element positioned within the cage to remove material
10 extending into the openings.

1 29. The device of claim 28, wherein:

2 the cage has rigidly connected elements which form the openings, the rigidly
3 connected elements being deformed when moved from the expanded position to the
4 collapsed position.

1 30. The device of claim 28, wherein:
2 the rigidly connected elements are deformed within an elastic range when
3 moving from the expanded position to the collapsed position.

1 31. The device of claim 28, further comprising:
2 a collapsible bag positioned to receive the material removed by the material
3 removing element.

1 32. The device of claim 31, wherein:
2 the bag is coupled to the material removing element.

1 33. The device of claim 28, wherein:
2 the cage forms 2-10 openings.

1 34. The device of claim 28, wherein:
2 the openings have a length of at least 1 mm.

1 35. The device of claim 28, wherein:
2 the openings have a size of at least 0.5 mm.

1 36. A method of removing material from within a previously implanted
2 stent, comprising the steps of:
3 providing a device having an expandable cage and a material removal element,
4 the expandable cage being movable from a collapsed position to an expanded
5 position, the expandable cage forming openings in the expanded position;
6 advancing the expandable cage to a position within a previously implanted
7 stent;
8 expanding the cage toward the stent so that material within the stent extends
9 into the openings of the expandable cage; and

10 removing material extending into the openings of the cage.

1 37. The method of claim 36, wherein:

2 the providing step is carried out with the expandable cage having integrally
3 formed elements forming the openings, the integrally formed elements being
4 deformed when moving from the collapsed position to the expanded position.

1 38. The method of claim 36, wherein:

2 the removing step is carried out with a material removing element having a
3 cutting surface, the cutting surface cooperating with a shearing surface on the cage to
4 remove the material.

1 39. The method of claim 36, wherein:

2 the providing step is carried out with the device having a collapsible bag for
3 holding the material; and
4 the removing step is carried out so that the material is contained within the
5 bag.

1 40. The method of claim 35, wherein:

2 the providing step is carried out with the collapsible bag being coupled to the
3 material removing element.

1 41. The method of claim 32, wherein:

2 the providing step is carried out with the expandable cage being biased toward
3 the expanded condition;
4 the advancing step being carried out by holding the expandable cage in the
5 collapsed position; and
6 the expanding step is carried out by releasing the cage to permit the
7 cage to expand.

1 42. A method of removing material from a blood vessel, comprising the
2 steps of:

3 providing an expandable cage and a material removing element, the
4 expandable cage being movable between a collapsed position and an expanded
5 position, the cage forming a plurality of openings in the expanded position and being
6 naturally biased toward the expanded position;
7 advancing the expandable cage through a blood vessel to a desired treatment
8 site, at least a portion of the expandable cage being restrained to hold the cage in the
9 collapsed position;
10 releasing the portion of the cage to permit the cage to expand so that material
11 inside the vessel extends through the openings in the cage; and
12 removing the material extending through the openings in the cage.

1 43. The method of claim 42, wherein:
2 the advancing step is carried out with the expandable cage being contained
3 within a sheath which holds the expandable element in the collapsed position.

1 44. The method of claim 42, wherein:
2 the providing step is carried out with the openings being formed by rigidly
3 connected elements.

1 45. The method of claim 44, wherein:
2 the providing step is carried out with the rigidly connected elements being
3 integrally formed elements.

1 46. The method of claim 45, wherein:
2 the providing step is carried out with the integrally formed elements forming a
3 smooth inner surface in the expanded position; and
4 the advancing step is carried out with the material removing element passing
5 along the smooth inner surface.

1 47. The method of claim 42, wherein:
2 the providing step is carried out with the expandable cage having at least three
3 openings.

1 48. The method of claim 42, wherein:

2 the providing step is carried out with the expandable cage having 2-10
3 openings.

1 49. The method of claim 42, wherein:

2 the providing step is carried out with the openings have a size of at least 0.25
3 mm² when expanded.

1 50. The method of claim 42, wherein:

2 the providing step is carried out with the openings each having a size of at
3 least 0.50 mm² when expanded.

1 51. The method of claim 42, wherein:

2 the providing step is carried out with at least one of the openings having a
3 length measured in a longitudinal direction of at least 1 mm.

1 52. The method of claim 42, wherein:

2 the providing step is carried out with at least one of the openings having a
3 length measured in a longitudinal direction of at least 0.5 mm.

1 53. The method of claim 42, wherein:

2 the expanding step is carried out with the expandable cage being expanded
3 within a stent.

1 54. The method of claim 42, wherein:

2 the providing step is carried out with the material removing element having a
3 flexible bag attached thereto for trapping the material which has been removed by the
4 material removing element.

1 55. A device for removing material from a vascular site, comprising:

2 a cage which is movable from a collapsed position to an expanded position,
3 the cage having 2-10 openings in the expanded position, the cage having an inner
4 surface; and

5 a material removing element positioned within the cage which removes
6 material extending into the openings.

1 56. The device of claim 55, wherein:
2 the cage forms 4-8 openings in the expanded position.

1 57. The device of claim 55, wherein:
2 the cage is naturally biased toward the expanded position.

1 58. The device of claim 55, further comprising:
2 a sheath;
3 the cage being contained within the sheath when in the collapsed position, the
4 sheath being retractable relative to the cage for exposing the cage and permitting the
5 cage to expand.

1 59. The device of claim 55, wherein:
2 the openings are formed by integrally formed elements.

1 60. The device of claim 55, wherein:
2 the openings have a size of at least 0.25 mm² when expanded.

1 61. A method for removing material from a vascular site, comprising the
2 steps of:
3 providing a device having an expandable cage and a material removing
4 element, the expandable cage being movable from a collapsed position to an expanded
5 position and having a plurality of openings when in the expanded shape;
6 advancing the device to a vascular site where material is to be removed;
7 expanding the expandable cage within the narrowed region of the blood vessel
8 so that material extends through at least some of the openings;
9 removing the material extending through the openings in the cage; and
10 vibrating at least one of the cage and cutting element during at least one of the
11 expanding and removing steps.

1 62. A method for removing material from a vascular site, comprising the
2 steps of:
3 providing a device having an expandable cage and a material removing
4 element, the expandable cage being movable from a collapsed position to an expanded
5 position and having a plurality of openings when in the expanded shape;
6 advancing the device to a vascular site in a patient where material is to be
7 removed;
8 expanding the expandable cage within the narrowed region of the blood vessel
9 so that material extends through at least some of the openings;
10 removing the material extending through the openings in the cage; and
11 releasing the cage; and
12 removing the device while leaving the cage within the patient.